HIGH RESOLUTION MAPPING OF INTERTIDAL AND SHALLOW SUBTIDAL SHORES IN KACHEMAK BAY, ALASKA*
by Jenny Cope, G. Carl Schoch**, Melissa Roberts, and Steve Baird

ABSTRACT

Monitoring biological communities for a response to natural or anthropogenic perturbations must acknowledge the inherent problem of large temporal and spatial variability of natural systems. Evidence suggests that highly stratified sampling designs with multiple replicates can lower the variability of abundance estimates for benthic populations. But an objective means of identifying sample sites based on physical forcing functions is generally not available for intertidal and subtidal shores. A method was developed to partition complex shorelines into physically homogeneous segments and to quantify the physical features known to influence benthic community structure. The 543 km shoreline of Kachemak Bay, Alaska was partitioned into over 3,000 alongshore segments and the physical features of each segment were quantified. Data from nearshore moored instruments and CTD transects were used to identify oceanic gradients. These data were assembled into a GIS spatial model to provide a powerful tool for identifying replicate benthic habitats. Replicate segments were randomly selected and sampled. Population abundance estimates from biological transects were extrapolated from small to larger spatial scales within the spatial limits imposed by oceanic scale variability. This method is a first step in studying the physical mechanisms causing a response in estuarine and marine biodiversity and benthic community structure.

Why do we need better maps of the coast?

- better resolution of small scale features
- more information
- quantitative data
- comparable spatial scales

Exposed rocky
Sheltered flat
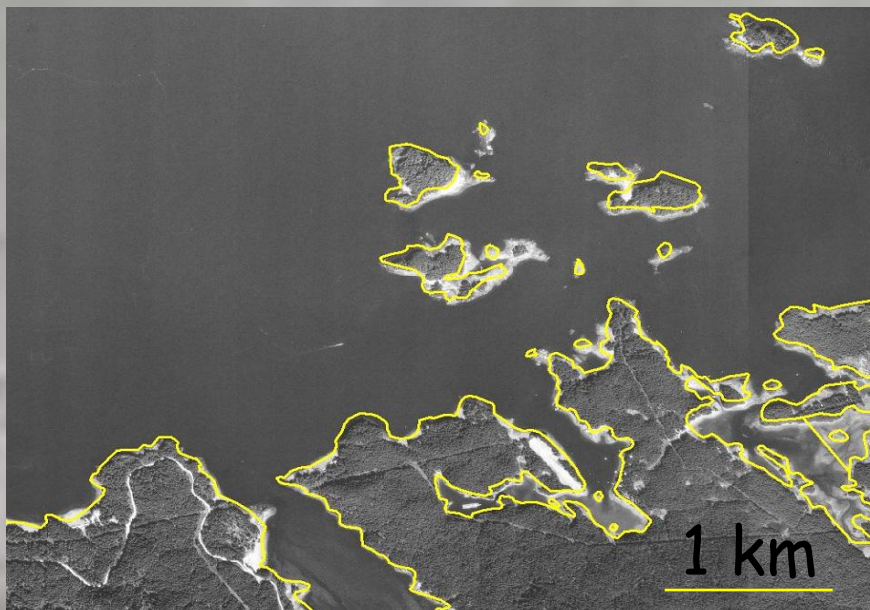Mixed sand and gravel
Exposed flat

1 km 1 km 100 m

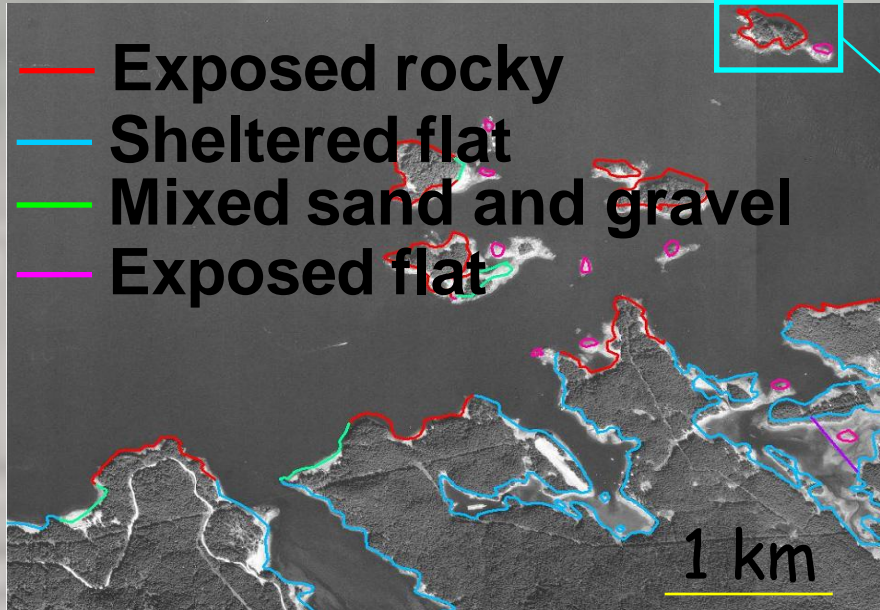Fig. 1. USGS 1:63,360 shoreline at Mean Sea Level.

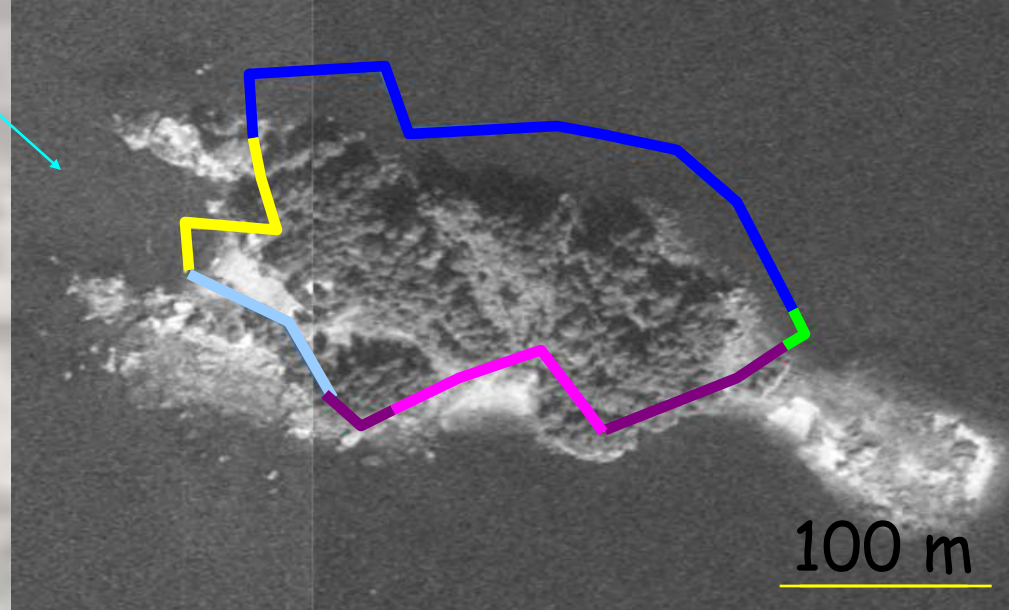Fig. 2. Environmental Sensitivity Index overlay.

Fig. 3. ShoreZone classification adds information to maps but is often overlaid on inaccurate representations of the shoreline.

METHODS

Materials
Tide controlled low altitude aerial photography

GIS and Access databases
Shoreline delineation

Calculated attributes
Wave power
Wave surge

Field Mapping
Shoreline segmentation and measurements
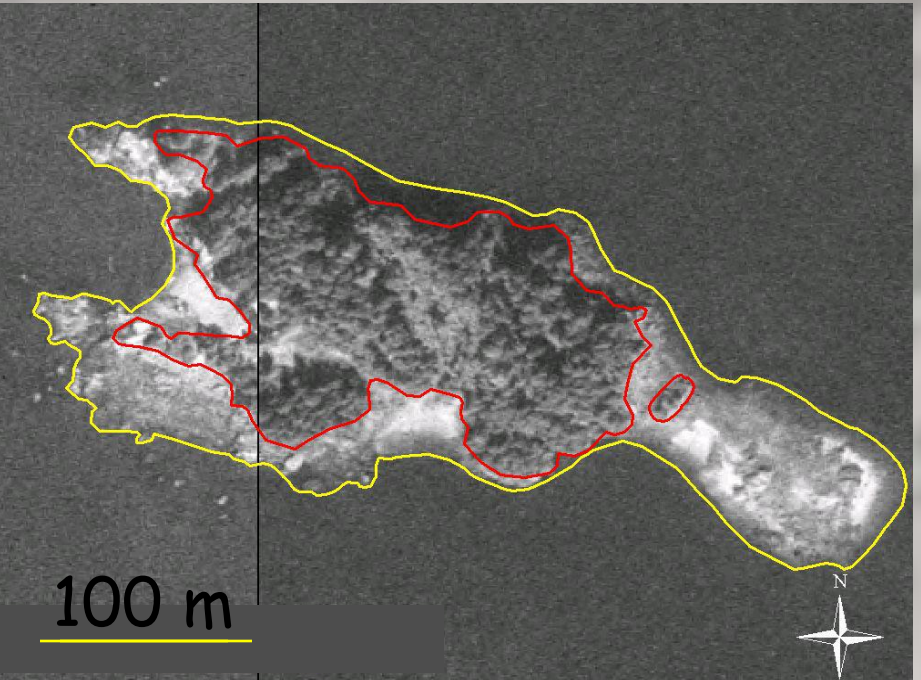
100 m 100 m 100 m

Fig. 4. The extreme high and low tide lines are delineated.
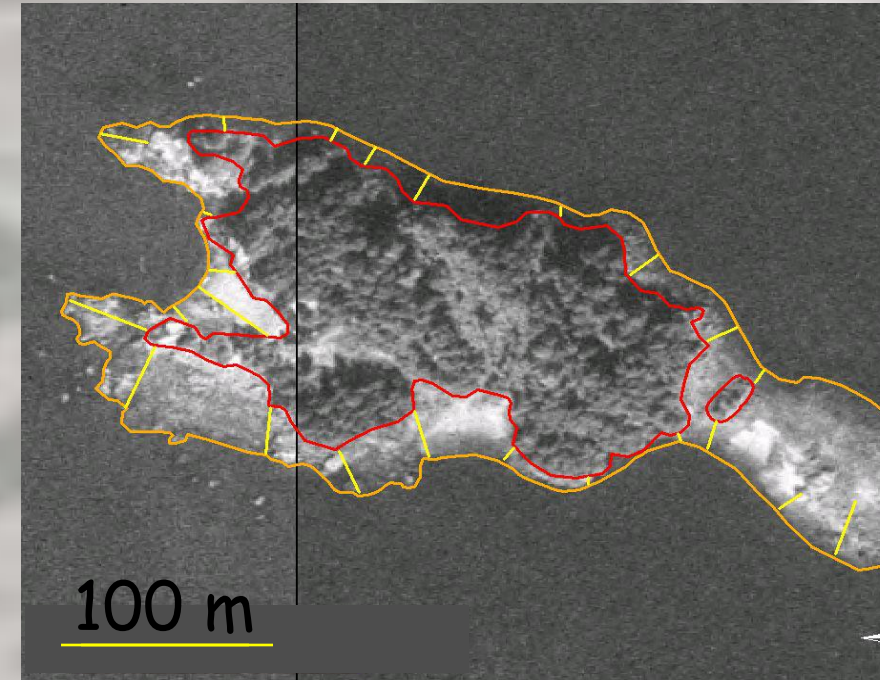
Fig. 5. Alongshore segments are identified from field surveys.

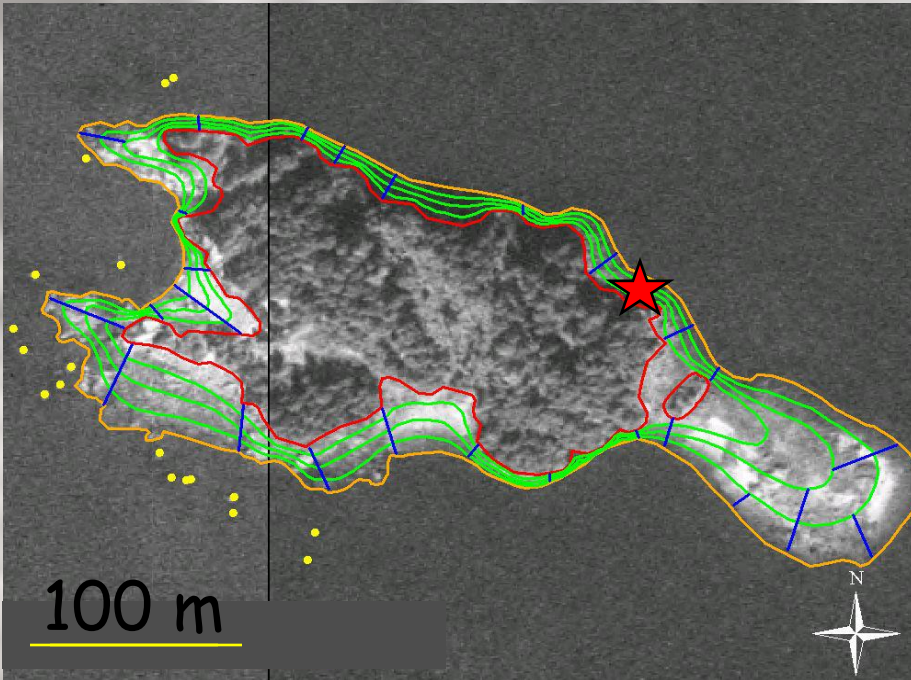Fig. 6. Attributes of across-shore zones are measured.

Sand flat
Sand flat
Sand flat
Sand flat
Sand flat
Sand flat
Sand flat

Cliff w/beach
Gravel flat
Cliff w/beach
Rock cliff
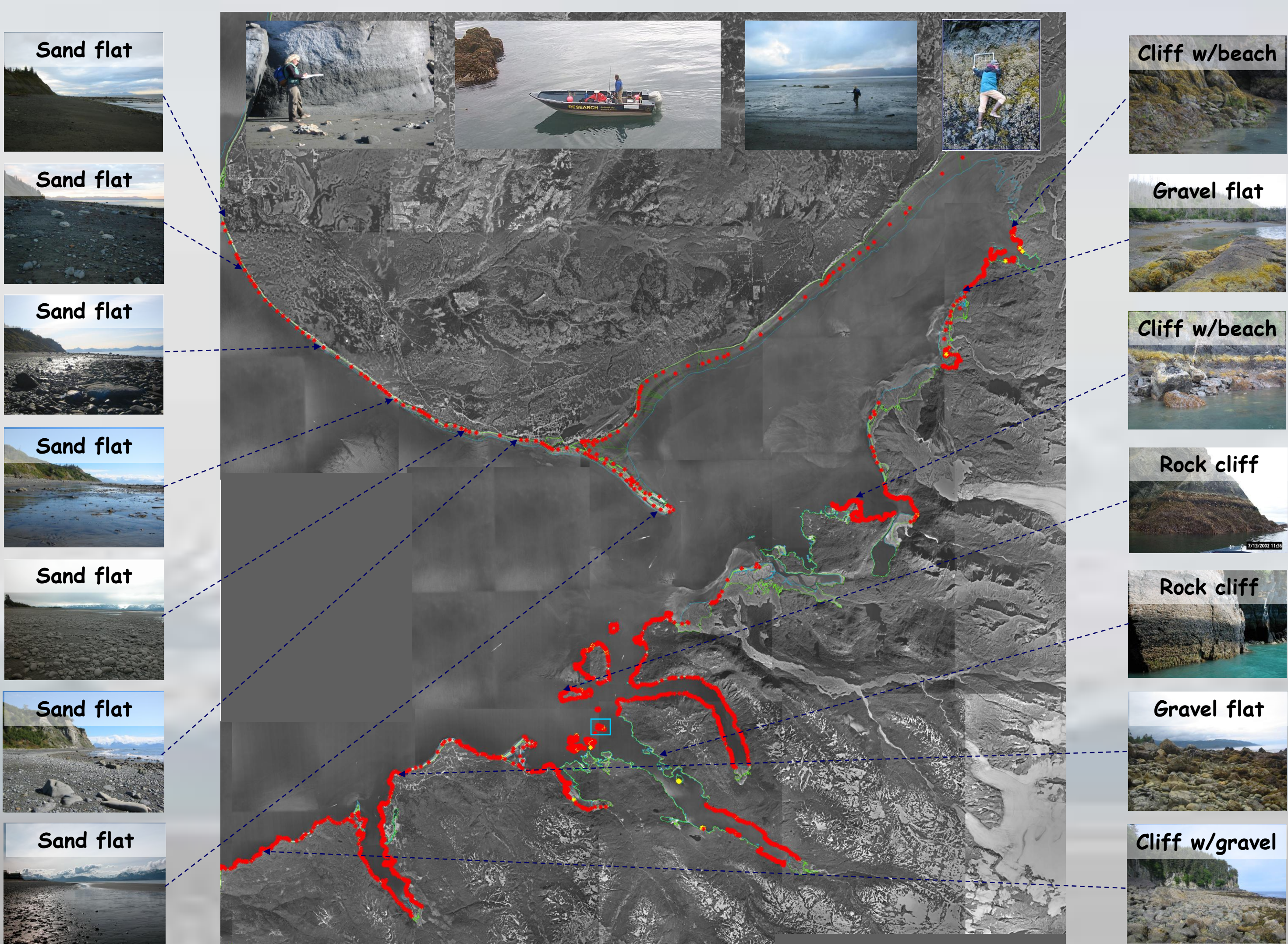Rock cliff
Gravel flat
Cliff w/gravel

Fig. 7. The intertidal habitats of Kachemak Bay were surveyed by either walking or boating the entire 543 km shoreline. A minimum horizontal mapping resolution of 10 m was established so that very small features could be ignored. Surveys were conducted when tide levels were less than .5 meters above Mean Lower Low Water. Over 3,000 segments were delineated, with 4 across-shore zones in each segment described and photographed.

RESULTS

Kachemak Bay Research Reserve Nearshore Habitat Database — A.

Alongshore segment: 2024
Oblique Photo
Location map

Latitude: 59.5433
Longitude: -151.4852
Shoreline type: Boulder
Area: 722 m Length: 47 m
Width: 23 m   Aspect: NE
Dynamism: Low
Wave runup: < 1 m

Across-shore zones

MHW	MSL		MLW
High	High middle	Low middle	Low

Data options

Next segment | Previous | Print | More photos

Low intertidal zone — B.

Alongshore segment: 2024

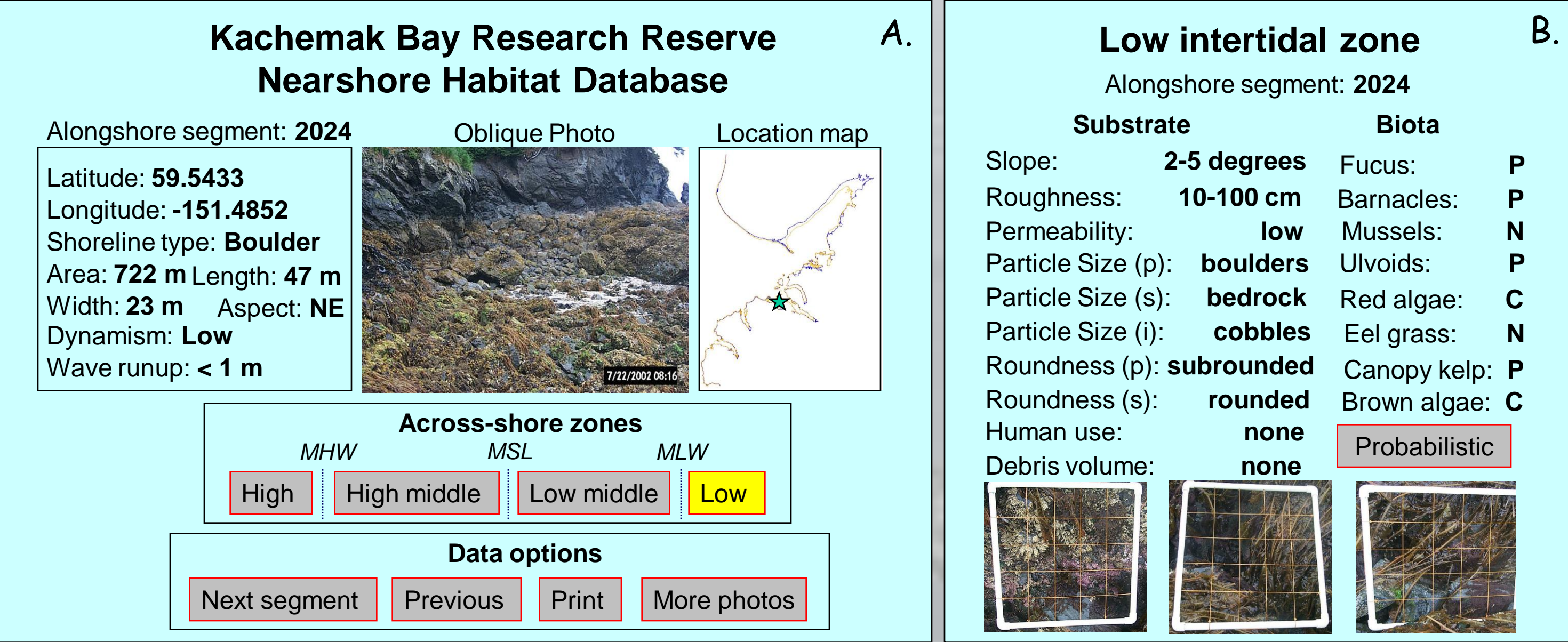| Substrate		Biota	
Slope:	2-5 degrees	Fucus:	P
Roughness:	10-100 cm	Barnacles:	P
Permeability:	low	Mussels:	N
Particle Size (p):	boulders	Ulvoids:	P
Particle Size (s):	bedrock	Red algae:	N
Particle Size (i):	cobbles	Eel grass:	N
Roundness (p):	subrounded	Canopy kelp:	P
Roundness (s):	rounded	Brown algae:	C
Human use:	none		
Debris volume:	none	Probabilistic	

Fig. 8. This example from the habitat database shows Alongshore Segment # 2024 on a small island on the south side of the bay (A), and data describing the low zone attributes (B). The partitioning of a continuous shoreline at scales of 10-100 m based on a suite of 12 quantifiable physical attributes results in polygons representing different vertical zones, nested within physically homogeneous alongshore segments. Aggregating shoreline partitions by these physical attributes results in groups of replicate shore segments that can be used for tests of biological similarity in controlled experiments, for monitoring programs requiring statistical power to detect change over time, and for probabilistic estimates of organism abundance at large scales based on limited biological sampling.

A.
Intertidal transect sites
Instrumented moorings

Gulf of Alaska
Out-flowing Current
Glacial Runoff
Halibut Cove
CTD Transect
19 km
Cohen Island
In-flowing Current
Seldovia
Port Graham

Trophic Distribution of Species Richness — B.
Suspension Feeders
Filter Feeders
Carnivores
Herbivores
Primary Producers
Port Graham, Seldovia Bay, Herring Islands, Halibut Cove

Invertebrate vs. Algal Species Richness — C.
Algae
Invertebrate
Port Graham, Seldovia Bay, Herring islands, Halibut Cove

Along-axis temp.
Summer water temperatures
Across-axis temp.
Seasonal variation in species richness — D.
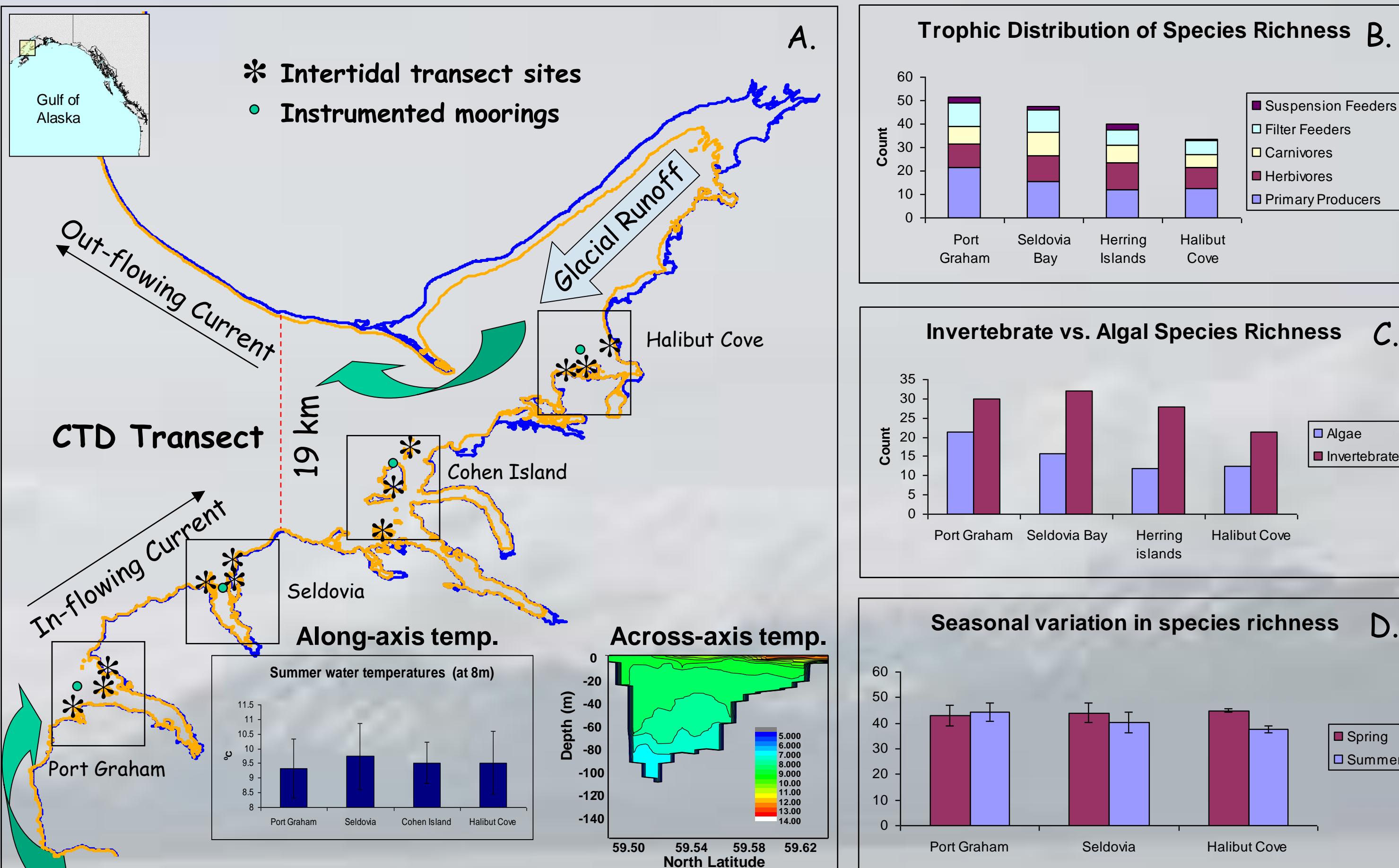Spring
Summer
Port Graham, Seldovia, Halibut Cove

Fig. 9. The map (A) illustrates where instruments with growth rate experiments and larval collectors were deployed adjacent to physically matched intertidal transect sites. Arrows indicate the primary direction of water flow into and out of the Bay. Inset figures show the weak along-axis and strong across-axis water temperature gradients. The graphs show the results of diversity surveys at the replicate intertidal sites. Total species richness decreases along the axis of the bay (B). This pattern seems to be driven by the decreasing number of algal species (C), and a salinity shift during the spring to summer transition (D).

Caged mussel growth rates — A.
Port Graham, Seldovia, Cohen Island, Halibut Cove

Larval recruitment — B.
Rockfish
Crabs
Shrimp
Snails
Bivalves
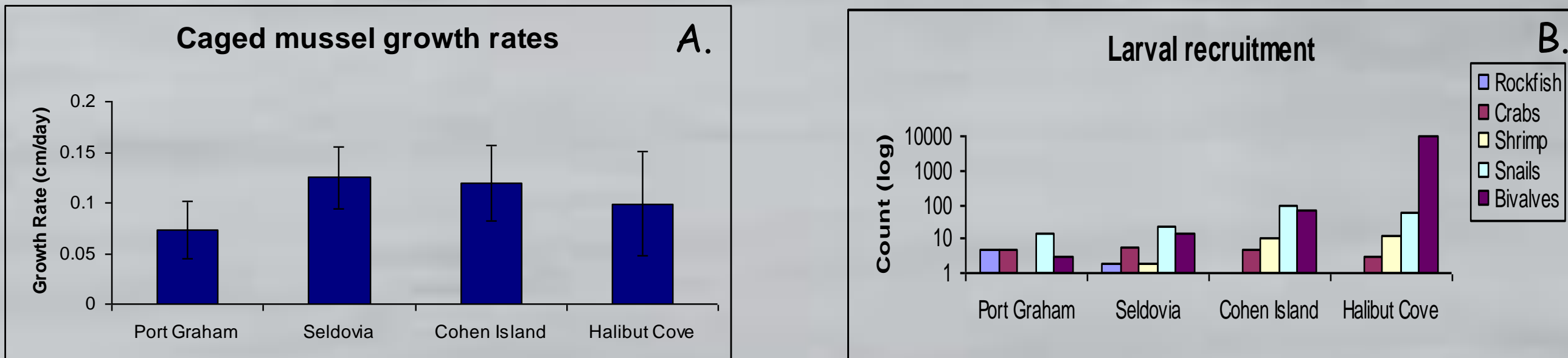Port Graham, Seldovia, Cohen Island, Halibut Cove

Fig. 10. The mean growth rate of intertidal mussels appears to be highest near the estuarine front (A). The abundance of rockfish and crab larvae recruiting to collectors generally decreases into the bay, while the recruitment of shrimp, snails, and bivalves generally increases (B).

SUMMARY

Quantifying change in nearshore benthic communities and their habitats is important to many research and management efforts. But generalizing change over large areas based on small scale quantitative studies is difficult. Spatially comprehensive high resolution inventories of abiotic shoreline attributes will provide information on the total area and spatial distribution of habitat types to allow assessments of generality. A procedure was developed that describes the physical attributes of shoreline habitats at a resolution relevant to intertidal algal and invertebrate populations. Aggregating shoreline partitions by these physical attributes results in groups of replicate beach segments. The degree of physical similarity among replicate beach segments will depend on the number and choice of attributes used to characterize a beach, the effort involved in quantifying segment attributes, the number and range of increments used to categorize each attribute, and the number of attributes chosen for segment aggregation. The low angle bedrock benches often used for ecological studies (above) are resistant to physical changes and make good platforms for controlled studies of biological interactions, but they may not represent the predominant habitat type of a region.